condition and the other in a plus condition the condition of the organ in the children will depend upon the germ cells (and hence on the parents) of the advanced parent. If half of its germ cells are in the minus condition, as may be the case, half of the children will have the organ in question in the minus condition. Even if both parents are in an advanced condition, if they both have the less advanced condition recessive, one quarter of their offspring will have the organ in a minus condition.

The foregoing principles help us to understand the reason for the degeneration that sometimes, but not always, follows inbreeding. If the children can not rise above the level of their parents but may fall below in respect to any organ, it is plain that if brothers and sisters were to mate the average of the offspring would rapidly run down hill to the zero condition of the organ. In the mating of cousins the same result would tend to occur, but not so rapidly and certainly. The more foreign blood introduced the less the danger of degeneration.

Another class of degeneration is illustrated by albinism. Studies that Mrs. Davenport and I have been making show that there are in human hair two pigments, black and red, occurring in various dilutions and combinations, as will be more fully set forth in our paper on human hair color to appear shortly in the *American Naturalist*. There are, however, cases of black (*N*) hair with no red (*r*) pigment, and of yellow or red (*R*) hair without black pigment (*n*). The gametic formula of the former is *Nr* and of the latter *nR*. The grandchildren of *Nr* and *nR* consorts will have hair of either of four kinds: black-and-red (*NR*, chestnut, or mahogany colored), jet black (*Nr*), clear yellow or red (*nR*), and colorless (*nr*); the latter are albinos. Studies that I have been making on albinos reveal an ancestry in conformity with this hypothesis. We see, then, that albinism is not a sport occurring in wholly arbitrary fashion; but a necessary, predictable result of certain combinations of gametes. The only part that inbreeding plays is to make more probable the necessary combination of gametes. The degeneration in this case follows from the union of two negative factors in dihybrids; and this is a common cause of degeneration.

CHAS. B. DAVENPORT

THE QUESTION OF CYCLOPIA, ONE-EYED MONSTERS

Two summers ago I found it possible to produce one-eyed fish embryos by means of $MgCl_2$ solutions in sea water.[1] At that time the spawning season of the fish used, *Fundulus heteroclitus*, was nearing a close, so that it was impossible to obtain material showing the early conditions of the defect or to rear the embryos in order to observe their actions after hatching.

During the present summer more extensive experiments have confirmed the fact that cyclopean embryos may be produced in any number desired by treating the eggs with $MgCl_2$ or $Mg(NO_3)_2$ solutions. The effect seems due to the Mg ion in the presence of certain sea-water salts. The embryos may be hatched and the cyclopean eye seems functional, many of the fish swimming in a normal fashion and responding to light. These free-living cyclopean fish may be kept for as long a period as the normal swimming embryos, a period of eight or ten days, after hatching, at which time all die of starvation, since the entire content of the yolk-sac has been absorbed and no other food is furnished. The cyclopean individuals could doubtless be reared if their proper food was known.

A study of these cyclopean embryos from the first appearance of the optic vesicles to hatching, both in life and sections, has proved that the earliest indication of an eye is just as truly cyclopean as it will be later. All degrees from a perfectly single organ through various conditions of doubleness to two intimately approximated optic cups may be found in young embryos. My former statement that the cyclopean eye resulted from a fusion of the elements of the two eyes after their formation, a statement based on comparisons of cyclopean eyes in late stages of development, is incorrect, as is also a similar idea advanced by Dr. Mall in his recent paper.[2]

[1] Stockard, *Archiv für Entw.-Mech.*, XXIII., 1907.

[2] Mall, *Jour. Morphology*, XIX., 1908.

The cyclopean defect, as Spemann[3] contended, is present from the first in the same condition that it will continue throughout development.

In mammalian cyclopean monsters the nose is prevented from descending as it normally does by the presence in its path of the median eye. The nose is thus above the eye and shows as a proboscis-like mass on the forehead. The nasal pits in the fish are laterally placed above the mouth and slightly antero-median of the two eyes. In the cyclopean monsters the two pits are generally united, though at times separate, and are situated unusually far forward and above the eye. The mouth in the normal fish is anterior, the lips projecting beyond the forward limits of the head. In cyclopean fish the median eye occupies this position and often projects forward, suggesting a miner's lantern in the front of the head. This anterior eye prevents the forward development of the mouth, so that its structures remain in a ventral position and hang down as a proboscis-like organ, recalling in a striking way the nose of the mammalian cyclops, and in fact the two are due to like causes. In the mammal the nose is prevented in its downward growth by the median eye, while in the fish the antero-median eye prevents the forward growth of the mouth arrangements.

The magnesium solutions induce the development of two types of one-eyed monsters. First, the true cyclocephali which may have a perfectly single median eye with one optic nerve, one lens and one pupil, or a median eye showing more or less double nature, having two optic nerves and paired retinæ, or in others entirely double eyes with two lenses and two pupils present. A second type of monster, which is new, may be termed *Monstrum monoculum asimmetricum,* a monster with one asymmetrical eye, since it has only one perfect eye, which is one of the normal pair of eyes occupying its typical lateral position. The one eye in all cases is perfect while its mate may be represented by either a small eye, a mere cellular mass indicating an optic cup, or again all evidence of the second optic cup may be wanting. This peculiar one-eyed condition occurs in a great many of the embryos in the various Mg solutions. Should such a monstrosity have been caused by mechanical injury, as cutting or pricking certain early brain areas, the evident conclusion would have been that one of the eye anlagen had been injured while the other had not. Any other interpretation would have been faced by the above conclusion as a criticism and it would have been almost impossible to meet. In the case of the Mg action it is clear that such embryos have developed one eye normally while the production of the other was in some way inhibited, although the anlagen of both were exposed to the chemical.

These embryos throw interesting light on the development of the crystalline lens. In many of them a lens forms from the ectoderm and differentiates independently of the influence of an optic cup. Some embryos with one lateral eye and the other wanting have a perfect lens on the eyeless side. The lens lies freely in mesenchymous tissue and is disconnected entirely from any portion of the central nervous system. Several experimenters, Lewis[4] and others, have held that the lens during its development is in a dependent relationship with the optic cup and they have shown that if the optic cup be removed a lens fails to form. The fish embryos are against the universal application of such a view. Spemann[5] has recently found that in one species of frog, *Rana esculenta,* the lens may arise independently of the optic cup stimulus and is self-differentiating.

To conclude—experiments now show that cyclopean fish embryos may be produced by the action of two salts of magnesium in sea-water solutions. The embryos exhibit various conditions of the cyclopean defect from the earliest appearance of the optic vesicles. Cyclopia is *not* due to a subsequent union or fusion of the two eye elements after their free and distinct origin.

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[3] Spemann, *Zool. Jahrbuch,* Supp. VII., 1904.

[4] Lewis, *Am. Jour. Anatomy,* 1904.

[5] Spemann, *Zool. Anzeiger,* XXXI., 1907.